Lessons learnt for Aeolus from the pre-launch validation campaigns with the A2D

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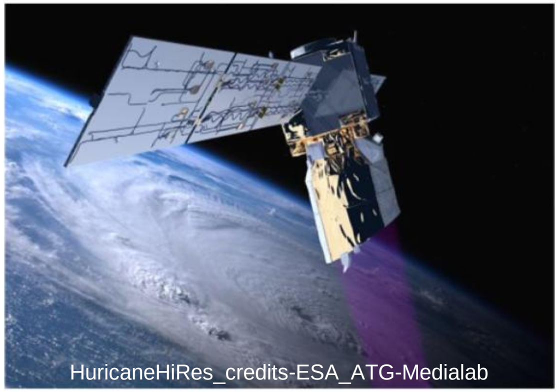
Objectives of A2D (ALADIN Airborne Demonstrator)

- Validation of ALADIN instrument with atmospheric signals before launch
- Derivation of conclusions for:
  - retrieval algorithms
  - on-ground and in-orbit tests
  - verification and calibration of satellite instrument



Acknowledgement:
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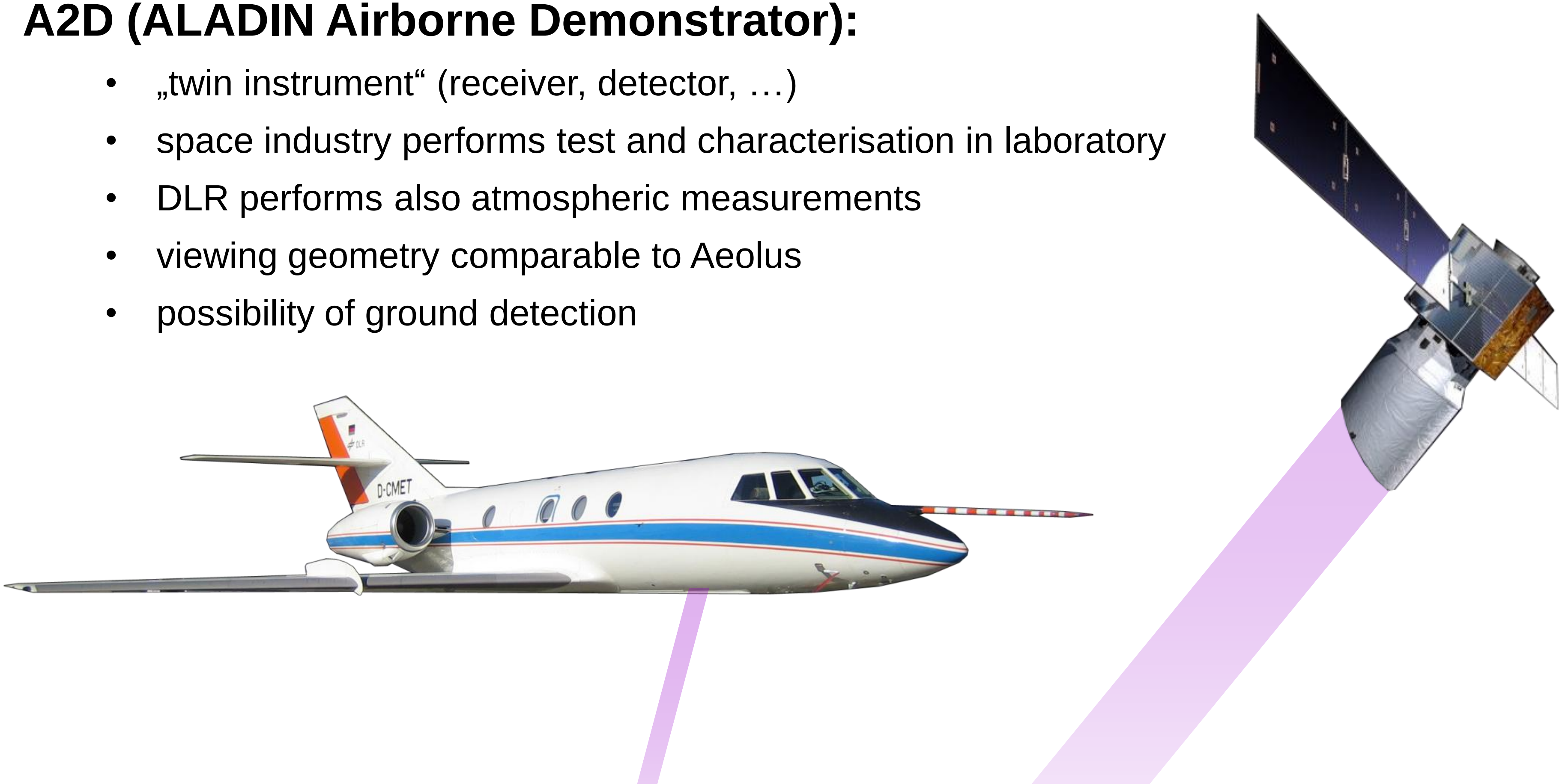
Comparison of Aeolus and A2D

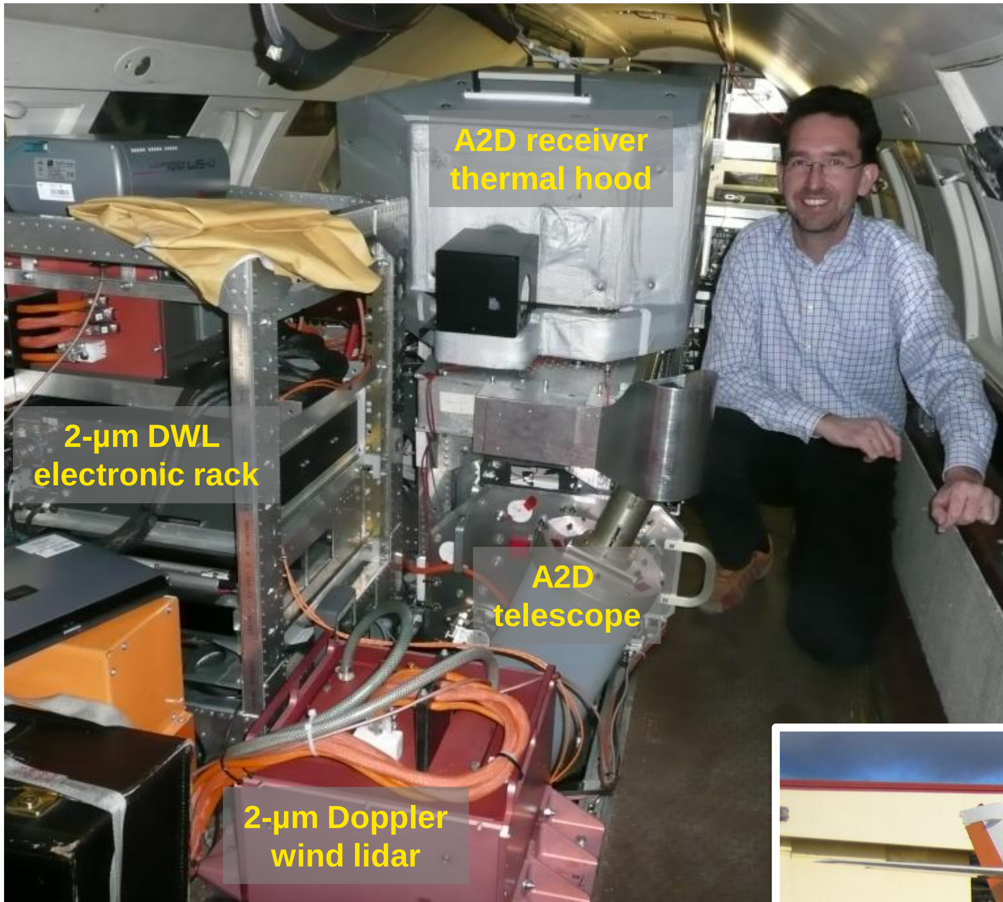
A2D (ALADIN Airborne Demonstrator):

- „twin instrument“ (receiver, detector, …)
- space industry performs test and characterisation in laboratory
- DLR performs also atmospheric measurements
- viewing geometry comparable to Aeolus
- possibility of ground detection



➔ A2D is particularly suited to verify the wind measurement & calibration strategy of Aeolus

The ALADIN airborne demonstrator



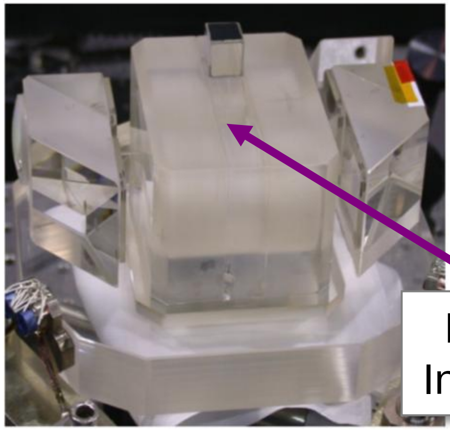
- Development of the A2D with the optical receiver and laser breadboard from ESA´s Pre-Development Programme
- Delivery of A2D and first flights of a direct-detection Doppler lidar worldwide in 2005
- Ground campaigns in 2006 and 2007
- First flights of coherent and direct-detection wind lidar on-board the same aircraft in 2007

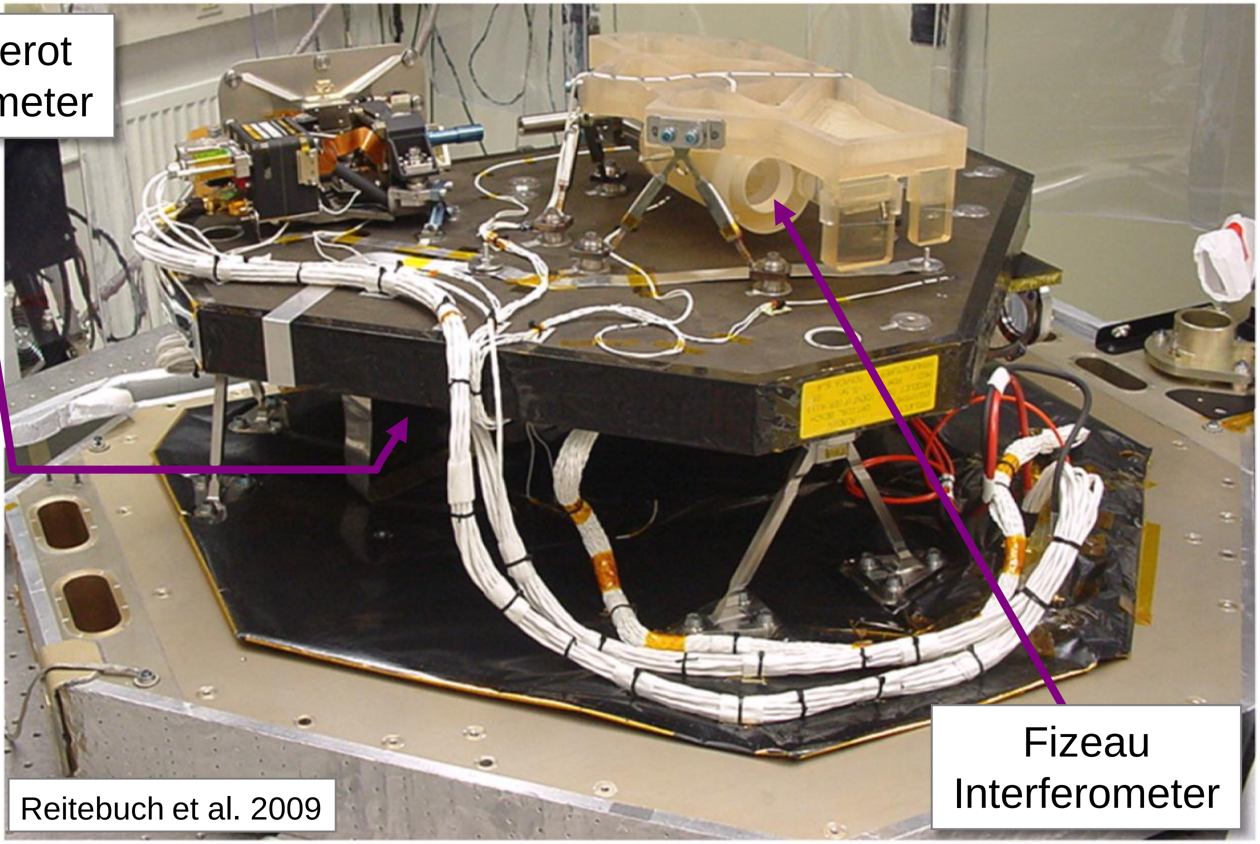
➔ **10 years of experience with A2D**

Payload in DLR Falcon aircraft during campaigns in 2007, 2008 & 2009

A2D hardware

The optical receivers of the airborne demonstrator from DLR (A2D) and the satellite instrument (ALADIN) are based on almost identical design





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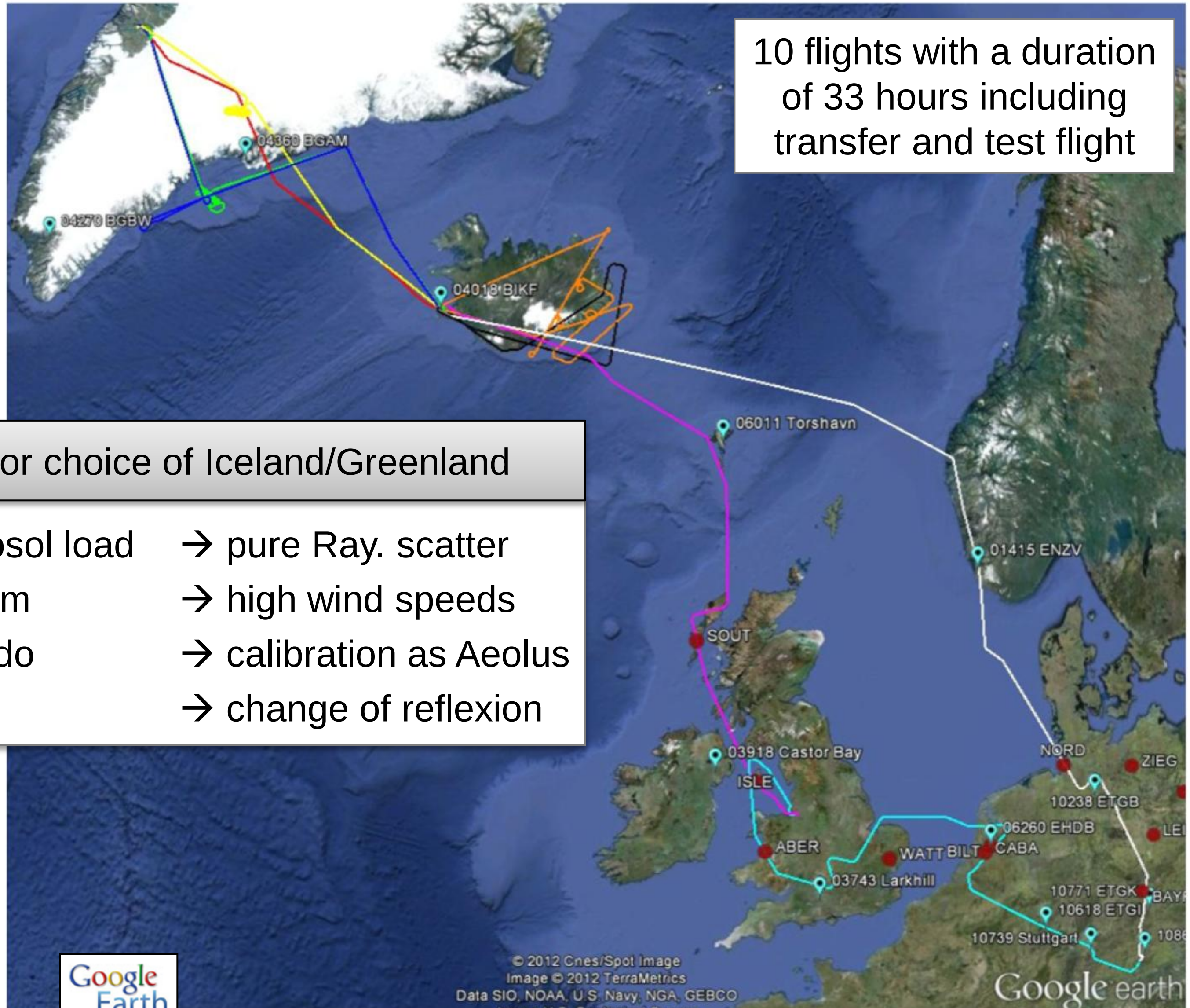
Novel technology

1. combined arrangement of two different spectrometers
2. Fizeau spectrometer for Mie channel
3. sequential implementation of Fabry Perot interferometers
4. custom-built ADM specific ACCD chip

3rd Aeolus campaign in Sept. 2009



10 flights with a duration of 33 hours including transfer and test flight

Reasons for choice of Iceland/Greenland

- low aerosol load → pure Ray. scatter
- jet-stream → high wind speeds
- ice albedo → calibration as Aeolus
- ocean → change of reflexion

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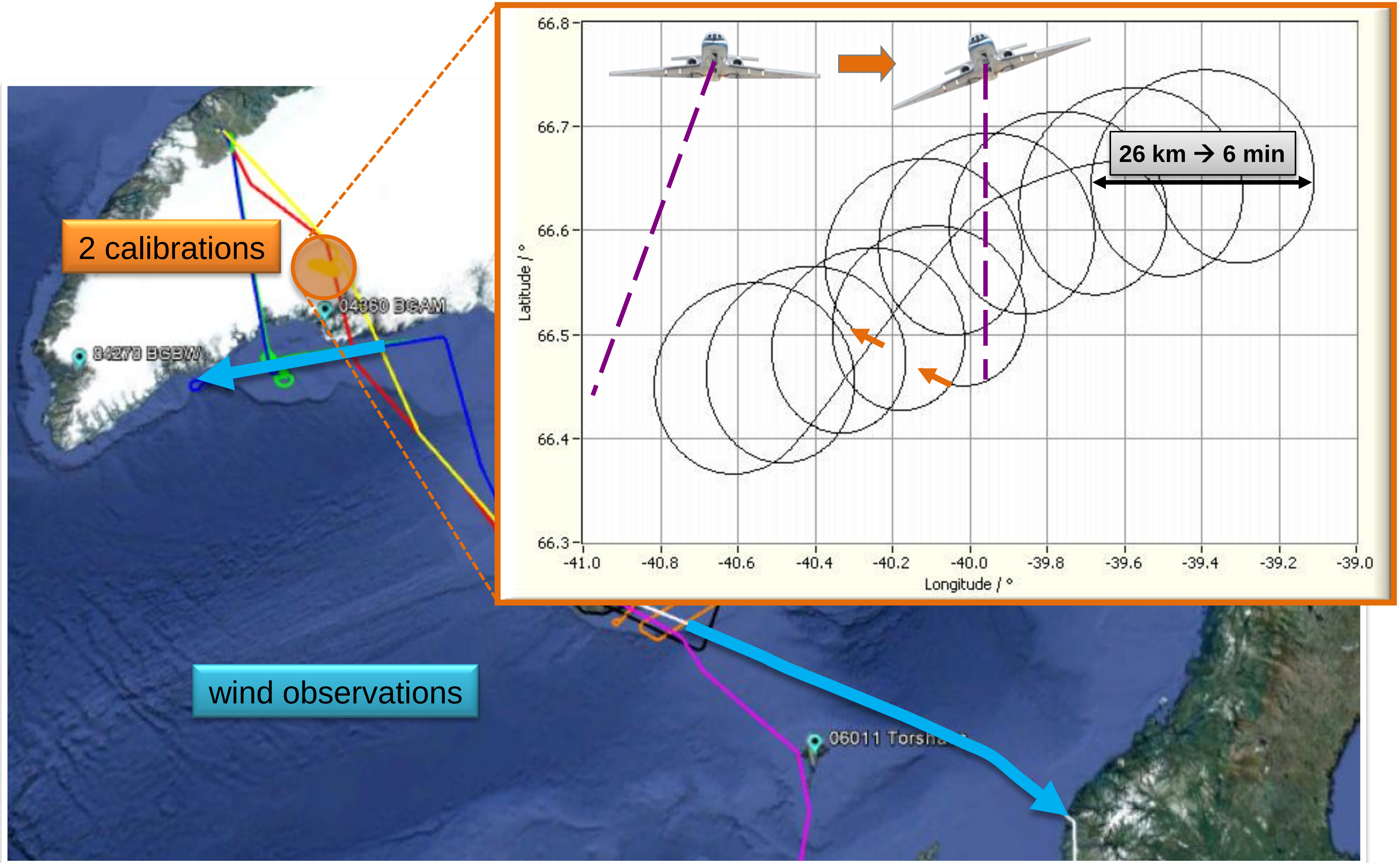
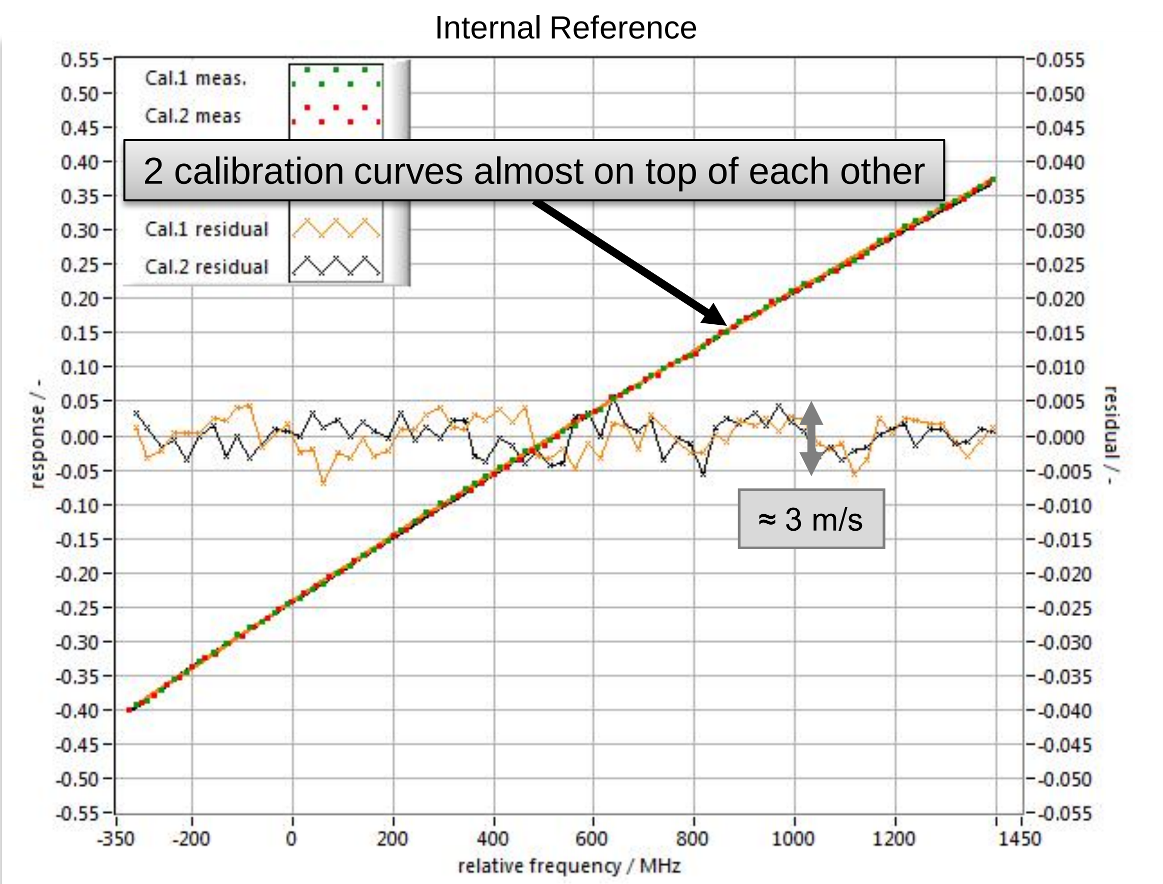
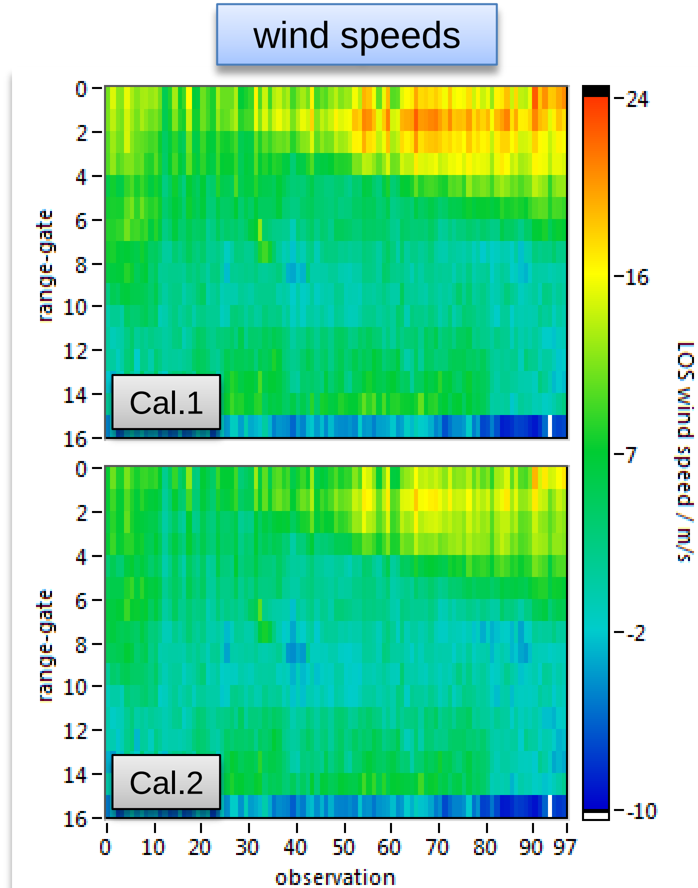
3rd Aeolus campaign in Sept. 2009



Instrument Response Calibrations of A2D



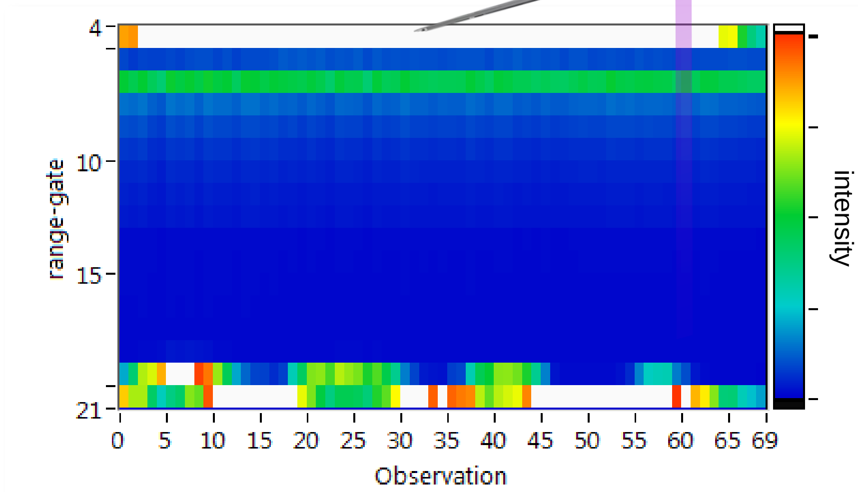


⇒ Apparently very consistent calibrations.
However, resulting in differences in wind speeds of up to ≈4 m/s.

Ground calibration ⇒ summation of signal

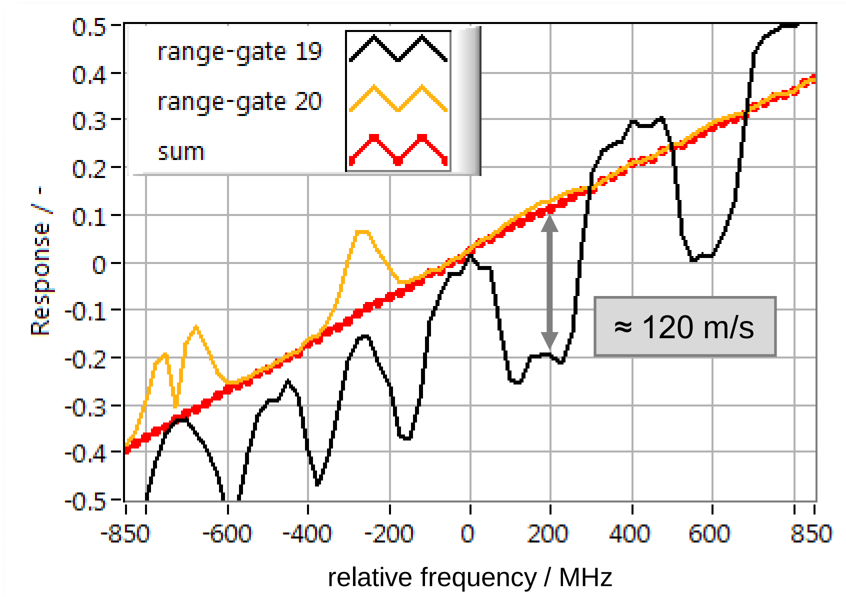
- Ground echo signal distributed over 2 „*range-gates*“

- deviations depending on non-perfect location of Rayleigh spots and Mie fringe on ACCD and range-gate overlap

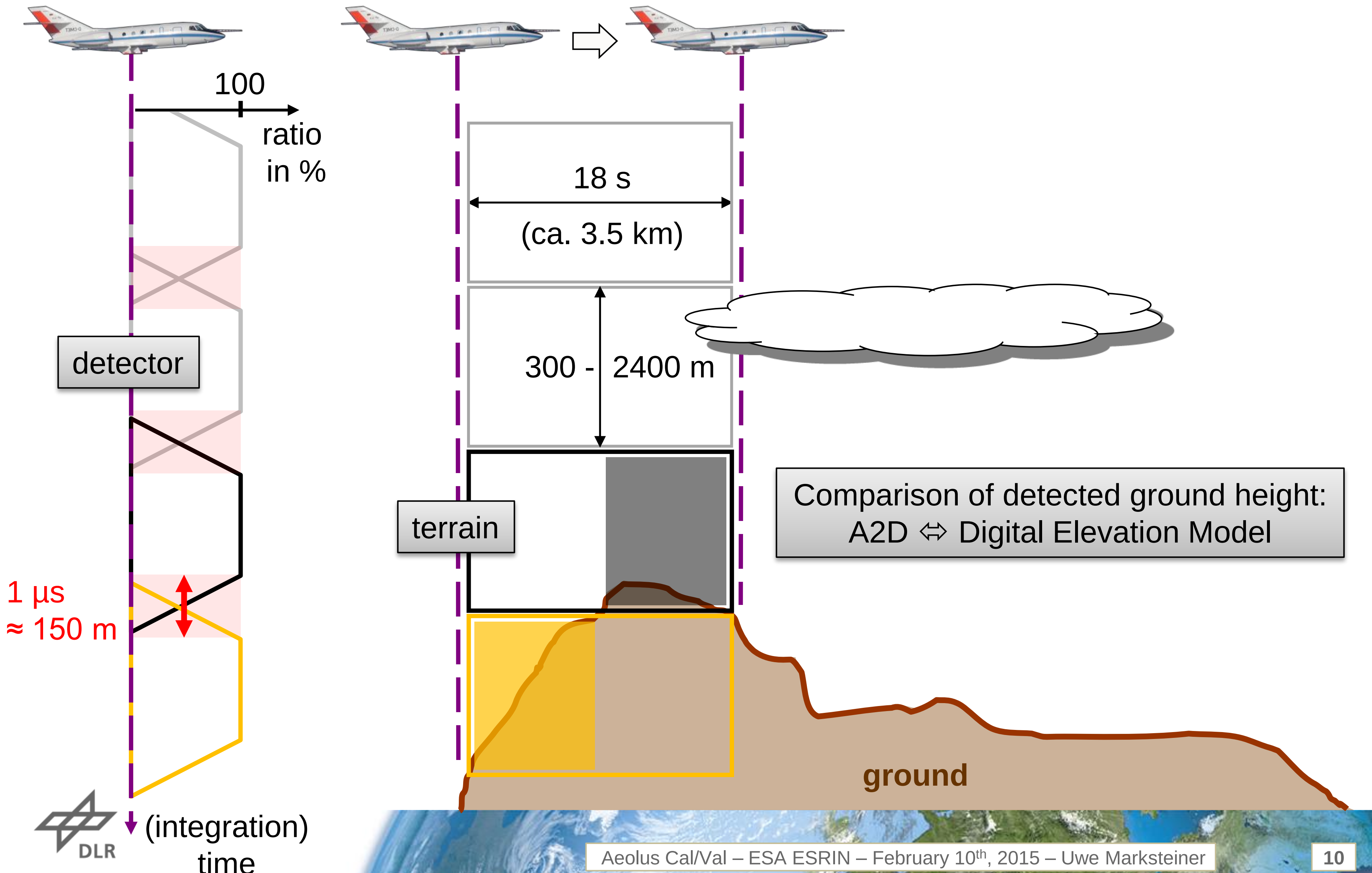


- in this case calibration curves of single „*range-gates*“ are partly deviating by ≈120 m/s

⇒ preceding summation of signal yields a useful calibration curve



Distributed ground echo & range-gate overlap



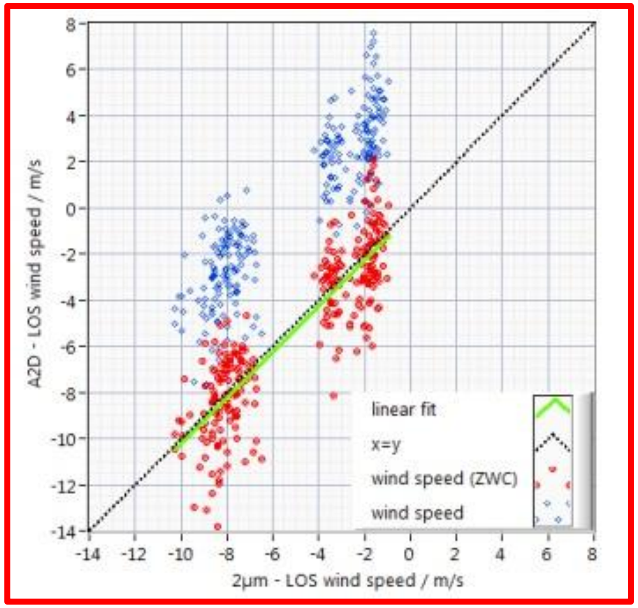
Comparison of detected ground height:
A2D ⇔ Digital Elevation Model

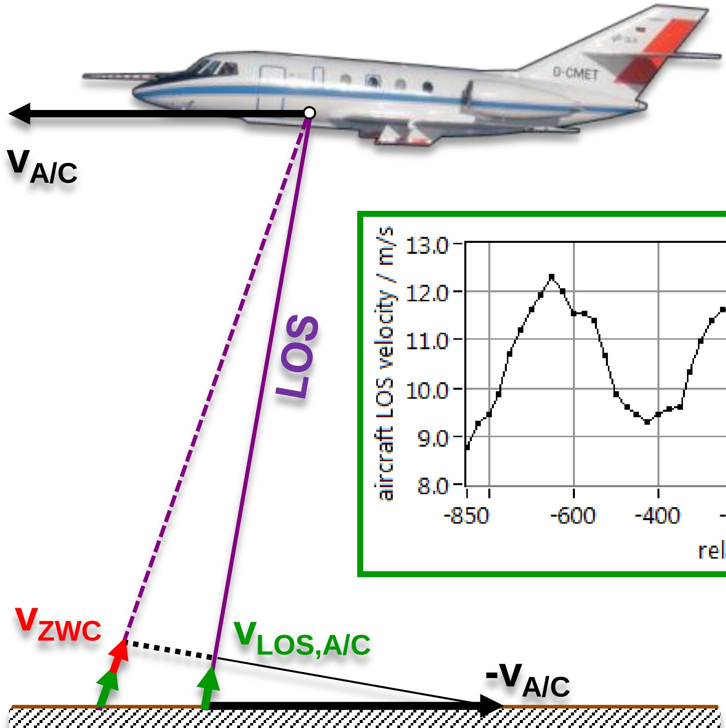
Line-Of-Sight wind and corrections

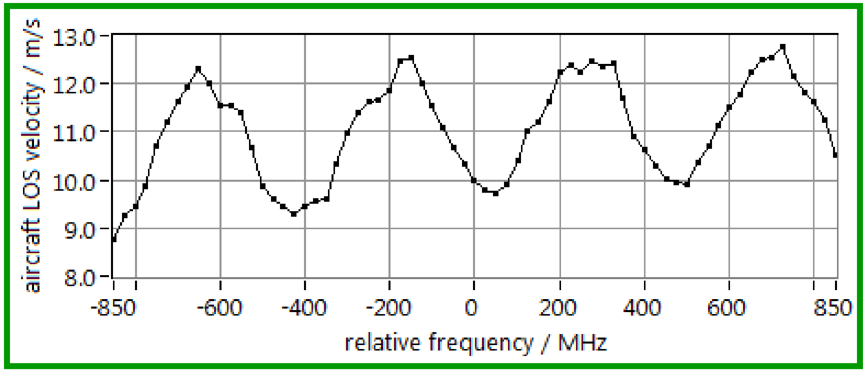
$$\boxed{v_{LOS,wind} = (\Delta f_A - \Delta f_I)\cdot\frac{\lambda_0}{2} - v_{LOS,A/C} - v_{ZWC}}$$

Additionally induced „virtual“ wind speed, e.g. due to:

1. component of aircraft velocity in direction of LOS (know)
2. Instrumental error or error in flight attitude (unknown)

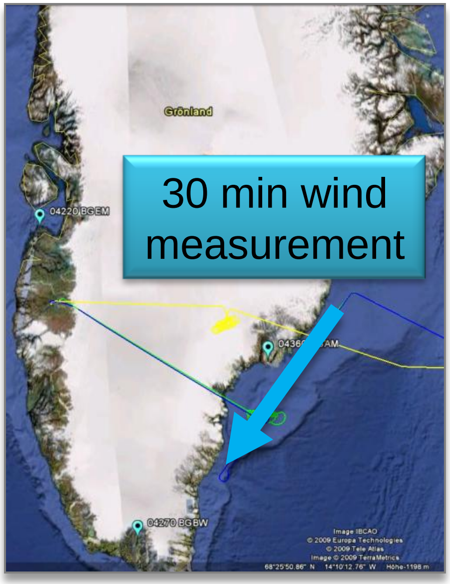


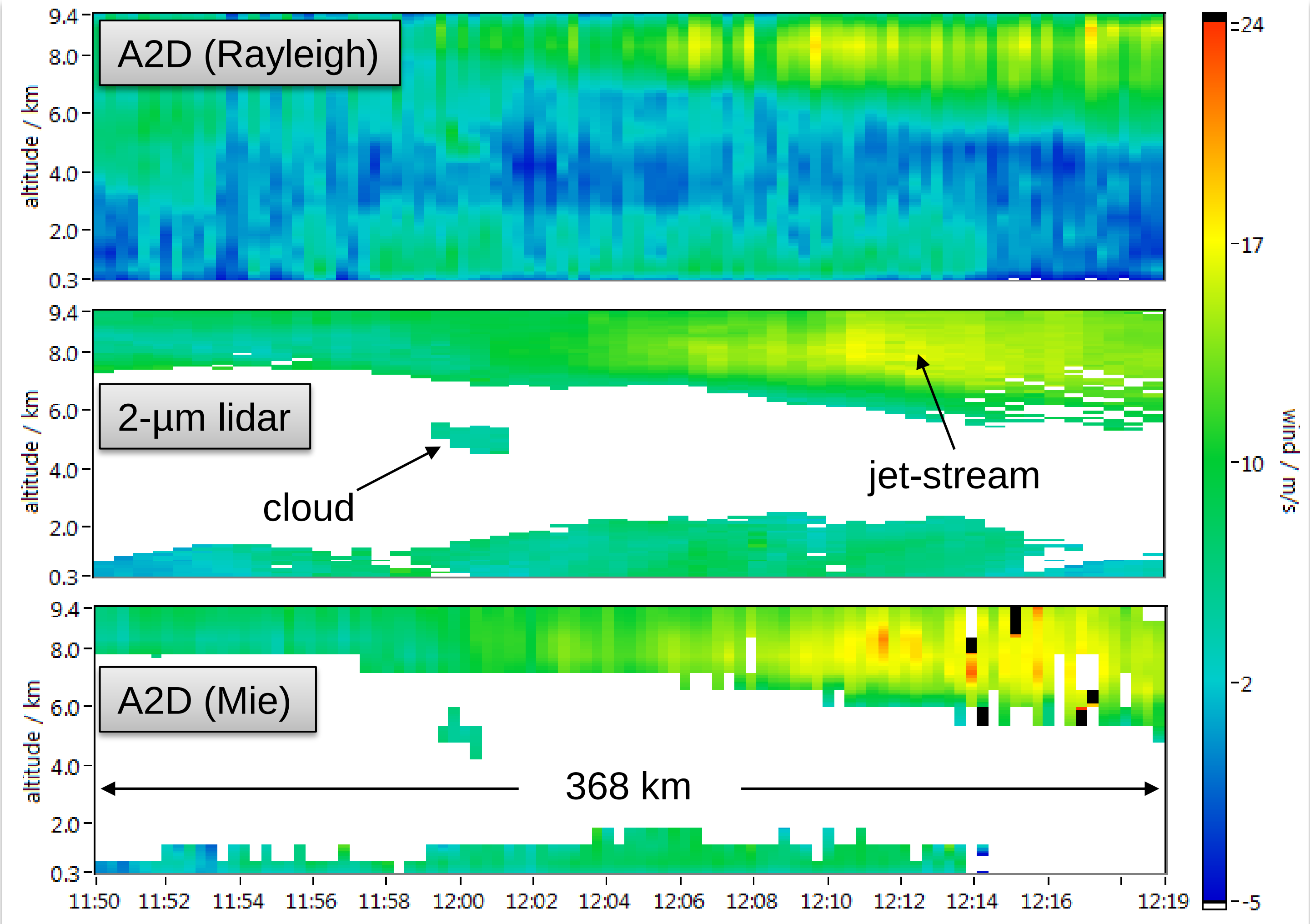




ground does not move ➔ signal must yield 0 m/s ➔ Zero-Wind Correction

1st airborne measurements of 2 different lidars in 2009

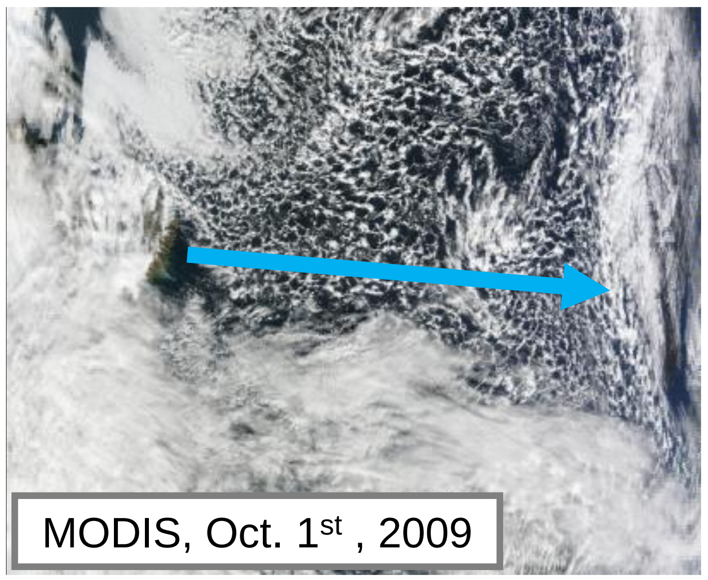




Airborne lidar observations and ECMWF model

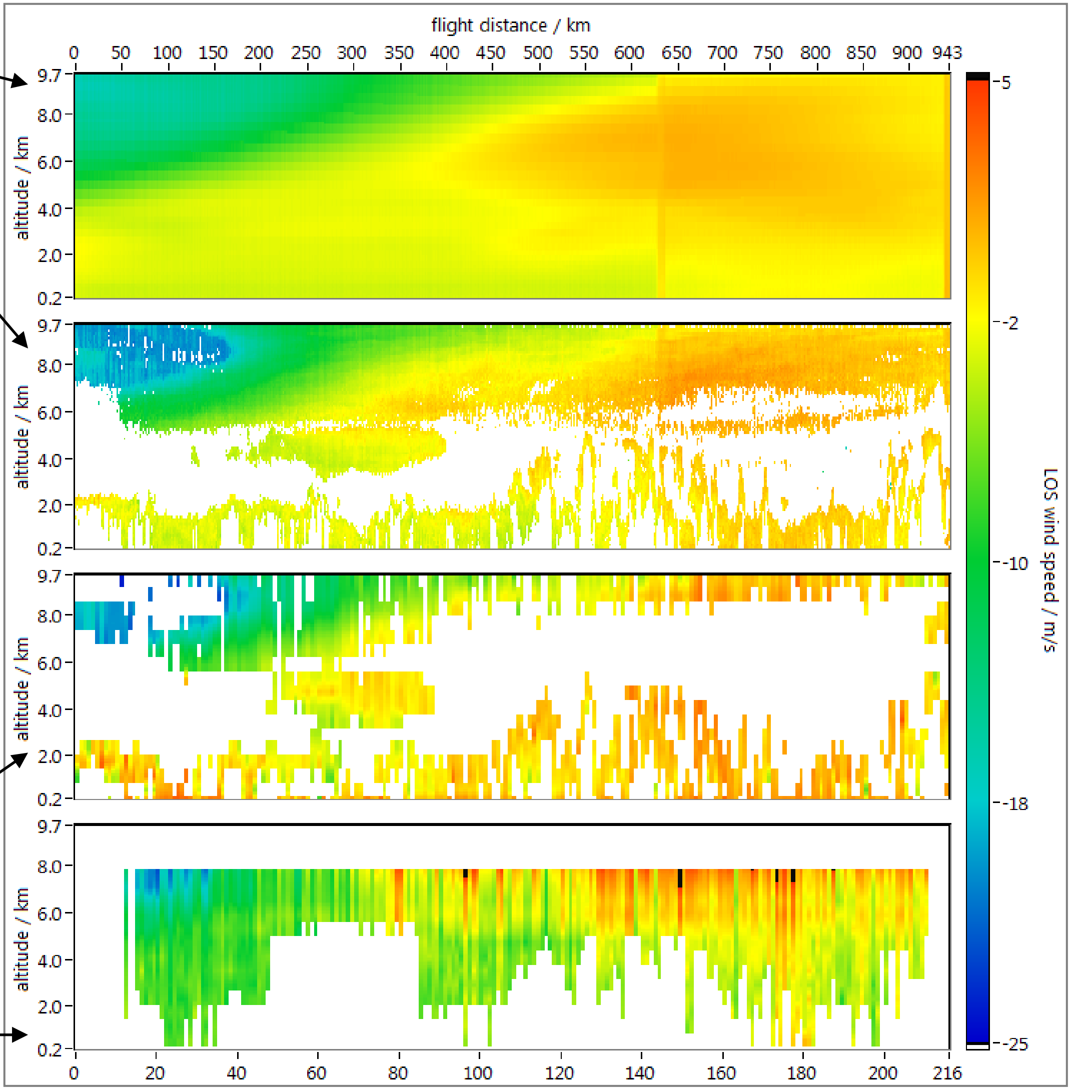
ECMWF

2-µm

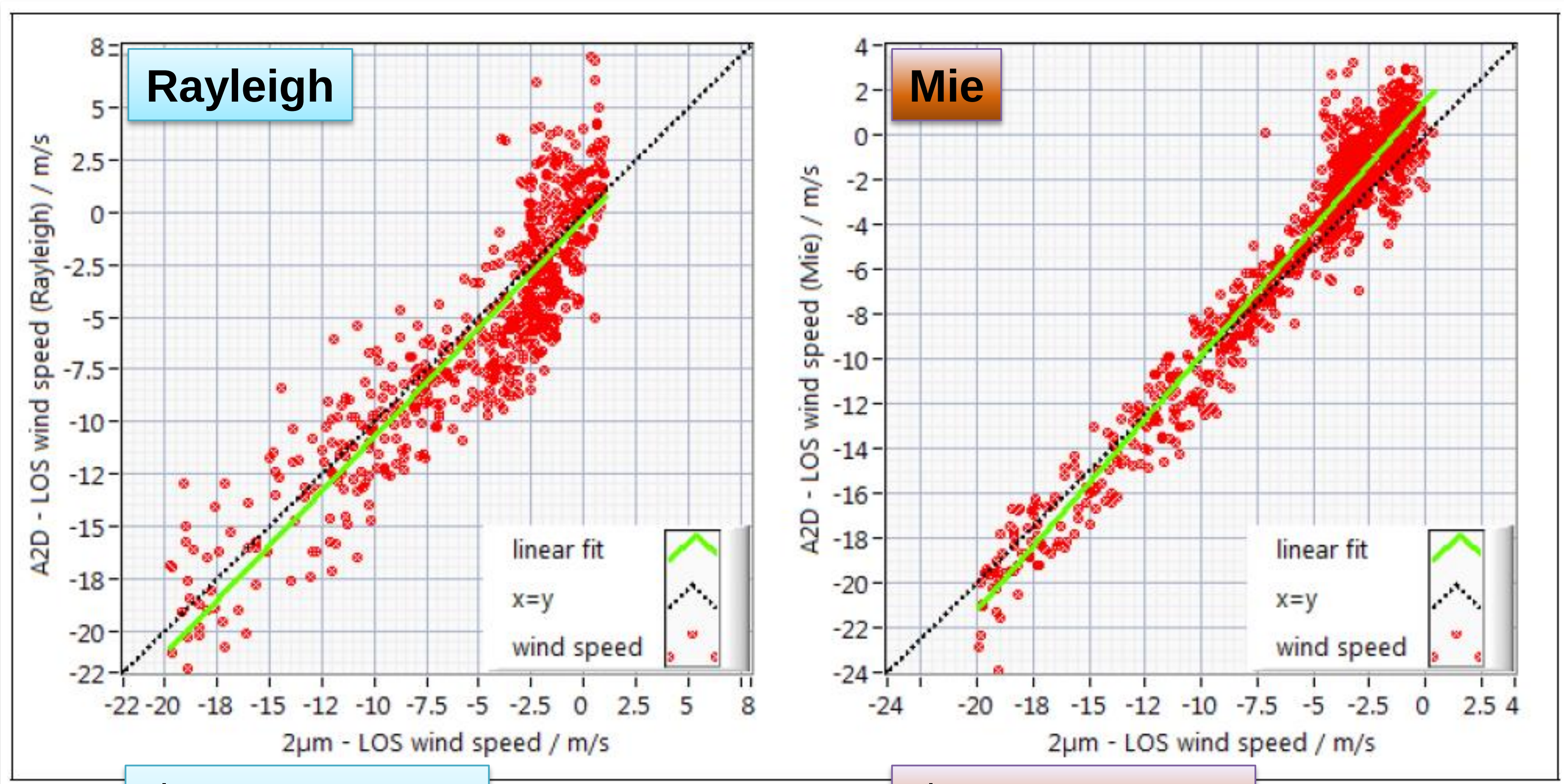


Mie

Rayleigh



Statistical comparison for ALADIN airborne demonstrator against 2-µm lidar



slope:	1.04
std. dev.:	2.5 m/s
# of points:	596

slope:	1.14
std. dev.:	1.5 m/s
# of points:	932

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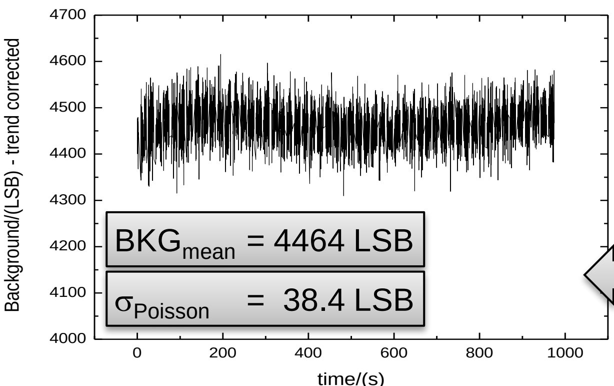
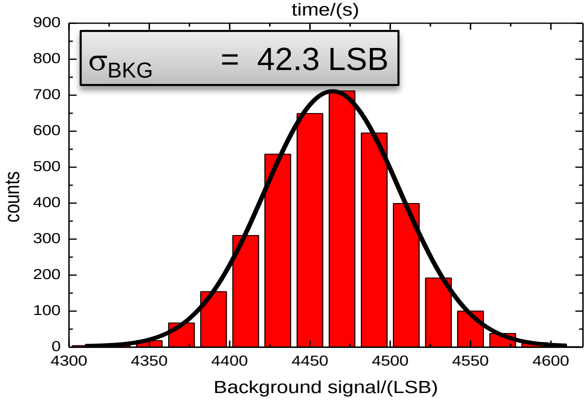
Ongoing study on A2D instrumental noise sources

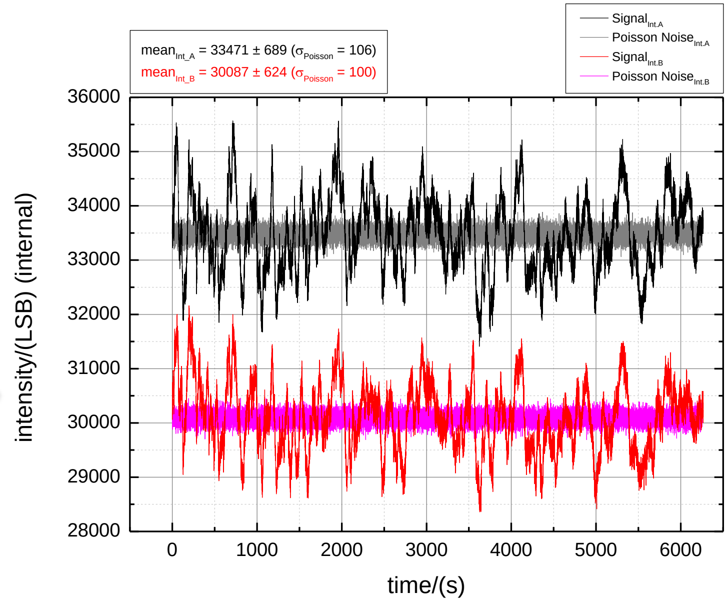
- An ideal (photon) counting process obeys Poisson statistics
- For Aeolus it is expected, that all instrumental noise sources are so small that Poisson Noise is the largest contributor („shot noise limited detection“)





Noise study for A2D to investigate instrumental errors:

- A2D is Poisson noise limited in regarding the background signal intensity ⇒ no increased electronic noise
- signal intensity of the Internal Reference Poisson noise limited up-to 40 s



Summary and Conclusion

- Experience of more than 10 years with operation of the unique A2D instrument
- New methods & new wind retrieval algorithms were developed using A2D data from airborne and ground measurements
- High quality wind measurements
- Principle of calibration and wind retrieval for Aeolus was validated with airborne demonstrator A2D at DLR during several ground and airborne campaigns
- The A2D will be used after launch for validation of Aeolus wind measurement and calibration strategy

Thank you very much!